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Source: *The American Journal of Psychology*, Vol. 44, No. 2 (Apr., 1932), pp. 300-307
Published by: University of Illinois Press
Stable URL: http://www.jstor.org/stable/1414829
Accessed: 25-12-2015 15:28 UTC

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EMOTIONAL EFFECTS PRODUCED BY THE INJECTION OF ADRENALIN

By HADLEY CANTRIL and WILLIAM A. HUNT, Harvard University

In his paper on the emotional action of adrenalin, Marañon[1] stated that the injection of adrenalin produced in his *Ss* only a "cold emotion," a feeling "as if afraid," "as if about to cry." True emotions, however, were aroused in a very few cases, both spontaneously and by suggestions; but he attributed these to the emotional predisposition of some *Ss*. He therefore concluded that the mere injection of adrenalin, with its consequent stimulation of the sympathetic nervous system, was not sufficient to cause a genuine feeling of emotion. It seemed to the present authors that Marañon did not give sufficient emphasis to those *Ss* who reported genuine emotions, and that he was not wholly successful in explaining them by predisposition. Cannon[2] and Wheeler[3] accept his results. Woodworth[4] follows Cannon. Bard[5] even goes to the extreme of not mentioning the cases involving genuine emotion. Landis[6] is more fair in his treatment, and mentions the need for further work on this point. Consequently, the present writers determined to test the emotional results of adrenalin on a group of normal observers, checking carefully any emotions that might appear.[7] It seemed desirable to approach the matter in a purely psychological way, rather than to use the combined clinical, medical, and psychological approach of Marañon.

*Accepted for publication February 14, 1931.

[1]G. Marañon, Contribution à l'étude de l'action émotive de l'adrenaline, *Rev. fr. d'endocrinol.*, 2, 1924, 301.

[2]W. B. Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage*, 1929, 356 f.

[3]E. B. Newman, F. T. Perkins, and R. H. Wheeler, Cannon's theory of emotion, *Psychol. Rev.*, 37, 1930, 305-326.

[4]R. S. Woodworth, *Psychology*, revised ed., 1929, 308.

[5]P. Bard, The neuro-humoral basis of emotional reactions, *Foundations of Experimental Psychology*, 1929, 480 f.

[6]C. Landis, The expressions of emotion, *ibid.*, 511.

[7]The authors were in no way motivated by a desire to prove or disprove the James-Lange theory of the emotions. Their interest lay wholly in the general implications of the work, and not in its application to any specific theory. Indeed, in view of James' exceedingly ambiguous article in 1894 (cf. The physical basis of emotion, *Psychol. Rev.*, 1, 1894, 516), the final formulation of his theory seems so vague and so open to personal interpretation that it appears almost useless for anything but the purpose of controversy.

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There was one point in particular on which the work might shed light. This is the supposed relation of pleasantness and unpleasantness to the antagonistic action of the cranio-sacral and sympathetic divisions of the autonomic nervous system. F. H. Allport[8] has based his theory of emotion upon this hypothetical relation. He states: "The cranio-sacral division of the autonomic, supplemented under certain conditions by the cerebrospinal system, innervates those responses whose return afferent impulses are associated with the conscious quality of pleasantness. The sympathetic division produces visceral responses which are represented in consciousness as unpleasantness."[9] In a recent popular presentation, F. H. Lund even goes so far as to call the sympathetic system the "tension nerves" and the cranio-sacral the "pleasure nerves."[10] As Hulsey Cason points out, this relationship still remains to be shown in spite of its widespread acceptance.[11] The feeling states produced by sympathetic innervation through the injection of adrenalin might have an important bearing on the question.

Technique

The general technique involved the intramuscular injection of 1.5 c.c. of adrenalin chloride. The standard Parke-Davis undiluted solution (No. 88) was used. Previous experimentation had shown that a dose of this size would produce a very definite reaction and still be harmless to the patient. As the interest was primarily in the psychological reaction, the only objective check used was the pulse rate. This was taken at frequent intervals. Previous work had shown this to be reliable, as the rate always suffers a slight drop at the onset of the syndrome. A secondary check is the noticeable increase in the strength of the pulse.

The *Os* used were Messrs. E. Land (*L*) and R. Proskauer (*P*), Harvard undergraduates; A. Wheelwright (*W*), graduate student in the Department of Physics; C. BoDine (*B*), Simeon Cantril (*SC*), and J. Goodman (*G*), medical students; S. Rosenzweig (*R*) of the Psychological Clinic; J. Logan (*JL*), a law student, and Mrs. E. Hunt (*EH*). In the first two-thirds of the experiment, the authors also acted as *Os* and their results are included under *C* (Cantril) and *H* (Hunt).

The experiment itself fell into three sections. In the first section, *W*, *L*, *P*, *B*, *G*, *C*, and *H* were all given a single injection of adrenalin. *O* was first asked if he were emotionally predisposed in any way at the time. (If so, he was dismissed until a later appointment). He was then required to rest for 5 min. After this his pulse was taken and the adrenalin injected. The *O* was then seated

[8]F. H. Allport, *Social Psychology*, 1924, 89 f.

[9]*Ibid.*, 90.

[10]F. H. Lund, *Emotions of Men*, 1930, 115.

[11]H. Cason, Pleasant and unpleasant feelings, *Psychol. Rev.*, 37, 1930, 230.

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at a table with pencil and paper and asked to write his introspections. His pulse was taken every few minutes. In two cases, two *O*s were seated in the same room, separated only by a screen.

In the second section, *C*, *H*, *L*, and new *O*s, *JL* and *EH*, were each given two injections. One of these injections, unknown to the *O*, consisted merely of a normal salt solution which afforded a check on the validity of the syndrome. The general procedure was the same as above.

In the final section, the experiment was repeated under more rigid conditions to check the previous data. The experimenters themselves did not observe. *JL*, *EH*, *L*, and two new *O*s, *SC* and *R*, were used. Each was given two injections of adrenalin. At the beginning of each sitting the *O*s were asked the three following questions:

Do you at present feel any disposition toward any particular emotional state?
Has anything (either physically or mentally) within the last few days or quite recently happened to disturb your normal state?
Can you recall any dreams that you have had in the past few nights?

If the answers to the first two questions were negative, and the third failed to reveal any disturbing dream content, the experiment proceeded. Otherwise, the *O* was dismissed until a later date. After a 5-min. period of rest, *O*'s pulse was taken and the adrenalin injected. His pulse was then taken again and he was handed the following instructions:

You have been given an injection of adrenalin. You are now asked to report orally to the experimenter and *as fully as possible* any physical or mental symptoms which develop. Do not omit anything, no matter how irrelevant it may seem to you. Try not to become impatient and try to keep your mind free from any material not called up by the actual situation.

The instructions were then removed and *O* was seated in an easy chair before a large grey screen. (In one case, that of *R*, the screen was unavoidably absent.) The *E* sat at a table behind the screen ready to take down the observations. No one else was in the room. *O*'s pulse was taken every 5 min. and also immediately upon the report of the symptoms of the syndrome.

Results

Physical symptoms. The physical symptoms which followed the injection of adrenalin were similar in the three sections of the experiment. The physical syndrome always consisted of a muscular tremor localized particularly in the legs and hands, a tremor in the voice, increased respiration, immediate slight decrease and subsequent rise in the pulse rate, and an increase in the strength of the heart beat. Several *O*s felt a tenseness in the viscera and others reported a tenseness localized in the chest.

Subsequent to the injection of the salt solution in the second part of the experiment, no *O*s reported any noticeable physical effects.

The following are a few typical introspections concerning the physical effects of the injection of adrenalin.

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"General muscular tremor and lack of faith in my muscular control. Breathing is more conscious and seems even more necessary than usual." (*C*)

"Definitely conscious of strong heart beat. Feel a tremor in all my muscles, particularly hands and legs. Tremor in voice." (*B*)

"Sudden release of muscular control. A tense feeling in chest and breath feels short. Heart pounding regularly and monotonously—like 'Bolero' (of Ravel)." (*JL*)

It should be mentioned that all the *O*s experienced a prolonged muscular tremor in the arms and legs. This effect lasted in some cases as long as two hours and is worthy of further physiological treatment in connection with the specific action of adrenalin.

Subjective aspects. The subjective aspects will be divided into three parts, corresponding to the three sections of the procedure. (1) In the first part *P*, *W*, and *G* reported only the physical concomitants of the syndrome. The following introspections illustrate this type of report.

"Trembling, particularly in hands. Voice shaky. Legs trembling. No psychic effects." (*W*)

"Trembling definitely in hands and arms. Resulting in difficulty in writing. Tremble in voice. Feel no more pleasant than before and unpleasant only as much as trembling gives me a feeling of unusualness. No emotions at all. Calm and collected. Seem to have all the externals of excitement but no feeling of excitement." (*G*)

B, *C*, and *H* reported a 'cold' emotion.

"Feel as though I had had a big scare, not fright but like a reaction after tremendous fright. Don't feel unpleasant. If there is any affective state it is somewhat pleasant. Certain bodily restlessness but no worries, cares, or mental anxieties." (*B*)

"Feel as I do either before an event in which I am to take an active part—such as a public appearance or athletic competition or before some great joy which I am anticipating. Likewise, it is much the same as the feeling I have after being scared for an instant by a danger which passes almost as soon as it appears. General restlessness and lack of faith in my muscular response—and yet I want to do something to relieve this uneasiness. . . . An undirected uneasiness without cause and purpose and hence I am annoyed. No positive pleasant or unpleasant emotions but the desire to have one of some kind to relieve my restlessness." (*C*)

"Bodily feeling of extreme nervousness. The bodily feeling almost swamps the psychic state, but the nervousness is wholly a matter of physical symptoms. I feel nervous, but I am not nervous. The reason seems lacking. I lack an object and the intellectual state is not fulfilled. To sum it up, I feel vaguely nervous, excited, but any definite emotion is lacking, and the excitement is a detached, bodily affair." (*H*)

L seemed to get something resembling a genuine emotion.

"Excitement (have felt like this in large class when I think I have a good idea, when raising my hand). No elation, but a background of elation. Feel light, as I used to in a burst of creative activity (writing). A pleasant state, possibly by association with such activity. Not unfamiliar. Used to attempt to bring on such states deliberately in adolescence. . . . During times of tremendous intellectual experiences in the past, times when my vision seemed peculiarly clear and far reaching, I have experienced similar reactions, but not even then so strongly. A tremendous illusion of power, vitality." (*L*)

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(2) In the second section of the experiment no *O*s reported any subjective symptoms subsequent to the injection of the salt solution.

Following the injection of adrenalin, *JL* noted marked physical changes but no psychic accompaniment.

"Muscles relaxed—sensation of no control. Throbbing of pulse through chest and back of head. Physical sensation as violent as any emotional reaction but no emotions present. Rather a distinct lack of them." (*JL*)

A 'cold' emotion was reported by *L* and *C*.

"Whole reaction seems localized in chest. Feel like breathing deeply to shake it off. Heavier and more and more like a feeling of great apprehension, except entirely localized. More accurately, chest feels as it does during great apprehension, but this feeling so localized that I can introspect detachedly as if I were considering a slightly injured finger. This reaction was dominated by a lack of confidence, a desire to withdraw, in short all the elements of fear except mental pain." (*L*)

"Feeling which is neither pleasant nor unpleasant. General excitement and I should like an object for it. Some annoyance at being unable to find relief from the excitement by some action." (*C*)

In the introspections of *H* and *EH* there is a genuine emotion noticed.

"The sound of my own voice trembling acts as context for fear. Feel extremely worried. Not exactly anxiety but a foreboding which is unpleasant. Whenever, without my mind on the symptoms, I do something like putting my hand to my face, the trembling of the hand gives me—on its perception—an extreme anxiety—not fear—but foreboding. No definite object but nevertheless an emotion." (*H*)

"I seem oppressed with a vague fear of something—feeling much the same as when I've lain awake all night, frightened that Bill might die. In spite of knowing the cause of his illness the fear was not specific and neither is this. I am oppressed with a nameless fear. I want to get away from it just as the night of Bill's illness I wanted to relax and sleep and tried to rationalize my fears. But that was impossible then and it is impossible now. It is decidedly unpleasant." (*EH*)

(3) In the third part the mere physical symptoms of the syndrome were reported once by *EH* and *SC* and twice by *R*.

Reports of 'cold' emotion were given once by *SC*, *L*, and *EH*, and twice by *JL*.

"A feeling in my abdomen as if I were going to get into an argument. Feeling as when somebody tells me they don't believe in vaccination." (*SC*)

"Felt a bit pleasant a moment ago. This succeeded by a disturbed feeling now, neither pleasant nor unpleasant. Decided predisposition to an emotion. Only a constant conscious attempt to keep calm prevented an emotion. It was an effort to keep calm." (*L*)

"Tenseness. The feeling as though something were going to happen that I expected to be disagreeable. An overwhelming desire to have something happen through which I might relieve the suspense." (*EH*)

"Feeling of something exciting going to happen. A desire for action. Throughout reaction there is a definite feeling of unrest which cannot be described as

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pleasant although there is nothing clearly unpleasant—might be summed up as uneasiness. I feel that during the whole reaction I should be readily subject to any kind of emotional suggestion." (*JL*)

"I feel very carefree and pleasant. Pleasant state of being continues although heart beat and trembling increased. Now a feeling of uneasiness and indifference. Feel as if I could either laugh or cry. As you do when drinks are being mixed and you are afraid you won't get one but hope you will. I want to do something but don't know what it is." (*JL*)

L reported a genuine and sudden emotion.

"Extreme fear was present, but no content for it at the time. Probably an unconscious reason but at the time nothing but fear. The strongest reaction yet. I found myself shaking, chest trembling, building up rapidly in intensity, whereupon I abruptly recognized that I was intensely afraid." (*L*)

It will be seen that while the majority of reports show no emotion, or at best a 'cold' one, there are cases of genuine emotions aroused which seem difficult to explain away as due to predisposition. The important thing to be noticed is that the bodily symptoms may occasionally satisfy some of the *O*s, while at other times they demand an intellectual content or reason before they will report an emotion. Some of the *O*s never appear able to experience an emotion without this content. In those *O*s not experiencing an emotion, there frequently appears a need for catharsis, a need to throw off the tension by completing the reaction. It is a desire to get the matter 'off their chests' by having an emotion and releasing the tension aroused. It is also apparent that there are no strict affective correlates of the adrenalin syndrome. The *O* may find it pleasant, unpleasant, or affectively indifferent. In one case we even have an exceedingly pleasant state resembling elation.

These results are summed up in the following Table I.

TABLE I

SUMMARY OF THE RESULTS OF THE EXPERIMENT

Classification of Reports	No. Reports
Total injections	22
Physical symptoms	22
Pleasant emotions	1
Unpleasant emotions	3
'Cold' emotions	10
No emotions	8
Unpleasant affect	3
Pleasant affect	3
Indifferent	5
No mention of affect	11
Need for catharsis	6

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Conclusions

On the basis of the above results we may conclude that in general the injection of adrenalin is not sufficient to produce an emotion. A 'cold' emotion may be aroused, but the lack of any object or reason for the emotion usually deprives it of its genuineness. In a few cases, however, the injection of adrenalin with its subsequent bodily symptoms is adequate to produce a genuine emotion; the mere bodily concomitants are sufficient for an emotional state without the presence of any object or reason.[12]

The experimental findings of the present investigation agree in general with those of Marañon but the present authors differ from him in their interpretation of the genuine emotions aroused in their experiment.

While the results of the present experiment may not justify the formulation of a general theory of emotions, the writers wish to venture a few theoretical implications. It seems to them that an analysis of the conscious emotional state would reveal its dependence upon the following possible factors.

(*1*) *A primary autonomic reaction* centered in the autonomic nervous system and involving changes in the vasomotor system, the respiratory system, the viscera, and certain peripheral changes such as sweating and muscular tremor.

(*2*) *Secondary behavioral reaction patterns*, both instinctive and learned, dependent upon the cerebro-spinal nervous system. This includes such reactions as flight, attack, facial expression, and vocalization.

(*3*) *An intellectual content.* By this we mean the presence in consciousness of some object or situation to which the emotion is directed and around which the emotion is intellectually organized. This involves the active participation of the higher logical processes, probably centered in the cerebral cortex.

The *usual* emotional state seems to involve a combination of (*1*) and (*3*). However, as the only criterion we have of a conscious emotional state is the *O*'s acceptance of it as such, the writers believe, on the basis of their results, that (*1*) is the only *sine qua non* for an emotion, for it may in some cases suffice itself to produce the

[12]These emotions resemble that described by Carl Sandburg as follows:

"We are afraid. What are we afraid of?
We are afraid of what we are afraid of.
We are afraid of this, that, these, those, them."

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emotional state. Nevertheless, such cases are rare. The status of (*2*) is at present unsettled, but this factor is probably of secondary importance.

The tendency of Marañon and others to explain the genuine emotions arising from the adrenalin syndrome by referring to predisposition seems unjustified to the present authors. True, in some cases, in addition to the report of the emotion, the *O* reported an associative content, viz. some reference to previous experiences or memories. But like associative content was also present in the report of 'cold' emotions, so that the difference cannot be explained on this basis. It seems to the authors that the differences of report are due to some critical attitude assumed by the *O*. In other words the situation must contain certain logical relationships in order that most *O*s experience a genuine emotion. In some cases, however, such a relationship is unnecessary. On the physiological level this may be due to differences in the strength of cerebral inhibition. These differences may be present not only between *O*s but within the same *O* at different times.

No doubt the physiological reaction involved in an emotion includes the basis for an affective state, but the report of pleasantness and unpleasantness seems to depend upon a special affective judgment which is not necessarily included in the report of the simple emotional consciousness.

The lack of any constant affective correlates of the adrenalin syndrome indicates that the theories which base unpleasantness upon the activation of the sympathetic division of the autonomic nervous system are palpably unfounded.

Finally, the need for cartharsis reported by some *O*s would seem to show that the emotional reaction contains within itself a definite drive to completion through expression. This resembles the tendency to closure exhibited by *Gestalten*.

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